Attorney Docket No.: 42390P9017 Patent Application

UNITED STATES PATENT APPLICATION
FOR

ENHANCED CONFIGURATION OF INFINIBAND LINKS

INVENTORS:

PATRICK DOYLE
a citizen of the United States,
residing at 767 NE Rogahn
Hillsboro, OR 97124

NELSON GE
a citizen of the United States,
residing at 92590 Mira Loma Drive, #403
Temeucula, CA 92592

PREPARED BY:

BLAKELY, SOKOLOFF, TAYLOR & ZAFMAN LLP
12400 WILSHIRE BOULEVARD
SEVENTH FLOOR
LOS ANGELES, CA 90025-1026
(303) 740-1980

EXPRESS MAIL CERTIFICATE OF MAILING

"Express Mail" mailing label number EL580086939US
Date of Deposit. December 29, 2000
I hereby certify that I am causing this paper or fee to be deposited with the United States Postal Service "Express Mail Post Office to Addressee" service on the date indicated above and that this paper or fee has been addressed to the Commissioner of Patents and Trademarks, Washington, D. C. 20231

Debbie Peloquin
(Typed or printed name of person mailing paper or fee)

Debbie Peloquin
(Signature of person mailing paper or fee)

December 29, 2000
(Date signed)

ENHANCED CONFIGURATION OF INFINIBAND LINKS

FIELD OF THE INVENTION

This invention relates to computer networks in general, and more specifically to the configuration of InfiniBand links.

BACKGROUND OF THE INVENTION

In order to overcome many of the problems and limitations that are inherent in common system bus technologies, new architectures are being developed. The InfiniBand architecture is a new standard based on switched serial links to device groups and devices. In the InfiniBand architecture, all devices are attached through a central, unified fabric of InfiniBand switches and links. InfiniBand architecture is intended to simplify and accelerate server-to-server connections and links to other server-related systems, such as remote storage and networking devices. InfiniBand is a merged proposal that was derived from the Next Generation I/O group (NGIO) and the Future I/O group (FIO).

The standards for the InfiniBand architecture are being developed by the InfiniBand Trade Association (ITA), and are provided in the architecture specification for the system. (InfiniBand Architecture Specification, Release 1.0, October 24, 2000) (hereinafter referred to as the "Specification") In addition to other features of InfiniBand architecture that are described in the Specification, there are specifications for connectivity configurations. Only certain limited configurations are provided in the Specification, these configurations being 1X, 4X, and 12X links.

For InfiniBand configurations, connections are defined by "physical lanes". A physical lane is comprised of one transmit differential pair of conductors and one receive differential pair of conductors. A 1X, 4X or 12X link is composed of one, four, or twelve physical lanes, respectively. The twelve possible physical lanes on a standard InfiniBand backplane connector are designated by lane identifiers 0 through 11. Under the Specification, a 1X link must use physical lane 0, a 4X link must use physical lanes 0 through 3, and a 12X link must use physical lanes 0 through 11, as shown in Table 1. No other possible configurations are specified, and only a single link is specified for any connector in use.

Table 1

Lane Identifier	Hex Number	Description
0	00	Used by 1X, 4X, and 12X links
1	01	Used by 4X and 12X links
2	02	Used by 4X and 12X links
3	04	Used by 4X and 12X links
4	08	Used by 12X link
5	0F	Used by 12X link
6	10	Used by 12X link
7	17	Used by 12X link
8	18	Used by 12X link
9	1B	Used by 12X link
10	1D	Used by 12X link
11	1E	Used by 12X link

The Specification thus defines the possible connectivity configurations using an InfiniBand connector as including only a single 1X link, a single 4X link, or a single 12X

link with rigid pin-outs. If a 1X link is present, eleven of the twelve physical lanes on a standard connector remain unused. If a 4X link is present, eight of the twelve physical lanes on a standard connector are unused.

As shown in Figure 1, a typical InfiniBand backplane connector **100** contains a plurality of connections **110**, these connections being the twelve physical lanes numbered 0 through 11 in this example. An InfiniBand backplane connector also includes a management link, bulk power connections, and auxiliary power connections, which are not shown in this illustration. Typically, connector **100** utilizes either the first connection in configuration **120** for a 1X link, the first four connections in configuration **130** for a 4X link, or all twelve connections in configuration **140** for a 12X link. No other connectivity configuration for the connector is provided in the Specification. The usage of a standard connector is therefore very limited, and does not allow for flexibility in configuration, or allow for the provision of multiple links on a single connector. For this reason, the limitations in the Specification standards do not allow sufficient options to precisely balance the data flow into and out of an InfiniBand module and do not allow full use of the capabilities of the InfiniBand architecture.

BRIEF DESCRIPTION OF THE DRAWINGS

The appended claims set forth the features of the invention with particularity. The invention, together with its advantages, may be best understood from the following detailed descriptions taken in conjunction with the accompanying drawings, of which:

Figure 1 is an illustration of the InfiniBand link portion of an InfiniBand standard backplane connector and the typical alternative connectivity configurations provided for said connector;

Figure 2 is an illustration of certain examples of expanded connectivity configurations possible using the InfiniBand link portion of an InfiniBand standard backplane connector according to one embodiment;

Figure 3 illustrates the typical backplane connections for an InfiniBand chassis and an InfiniBand module;

Figure 4 illustrates the backplane connections for an InfiniBand chassis and an InfiniBand module and the process of requesting a connectivity configuration and responding to such request according to one embodiment;

Figure 5 is a flow diagram illustrating the operation of an InfiniBand module according to an embodiment; and

Figure 6 is a flow diagram illustrating the operation of an InfiniBand chassis according to an embodiment.

DETAILED DESCRIPTION

A method and apparatus are described for configuring expanded InfiniBand links.

In the following description, for the purposes of explanation, numerous specific details are set forth in order to provide a thorough understanding of the present invention. It will be apparent to one skilled in the art that the present invention may be practiced without some of these specific details. In other instances, well-known structures and devices are shown in block diagram form.

The present invention includes various steps, which will be described below. The steps of the present invention may be performed by hardware components or may be embodied in machine-executable instructions, which may be used to cause a general-purpose or special-purpose processor or logic circuits programmed with the instructions to perform the steps. Alternatively, the steps may be performed by a combination of hardware and software.

Under one embodiment, the possible connectivity configurations for the InfiniBand architecture are expanded beyond the configurations provided in the Specification. Different links are possible under this embodiment, and multiple links may be provided simultaneously using the physical lanes defined by the Specification. Under this embodiment, the requirements of the Specification continue to be met, and the limited connectivity configurations that are provided in the Specification remain available.

One embodiment utilizes a standard InfiniBand backplane connector to allow connectivity configurations beyond those provided in the InfiniBand Specification. An embodiment allows a combination of different links to be provided simultaneously on a

single connector. As shown in Figure 2, InfiniBand backplane connector **200** contains a plurality of connections **210**, which are physical lanes 0 through 11 in this illustration. An InfiniBand backplane connector also includes a management link, bulk power connections, and auxiliary power connections, which are not shown in Figure 2. Under one embodiment, connector **200** could simultaneously provide for a 1X link through utilization of configuration **220**, a 4X link through utilization of configuration **230**, a 1X link through utilization of configuration **240**, and a 4X link through utilization of configuration **250**. Under various embodiments, up to twelve 1X links or up to three 4X links could be established on a standard InfiniBand backplane connector that contains twelve physical lanes. The configurations described here and illustrated in Figure 2 are meant solely as an example of the usage of a single connector under one embodiment, and such configurations do not limit how the invention may be implemented. Many different links and combinations of links are possible using the invention.

According to one embodiment, an expanded connectivity configuration may be obtained by making a request for the configuration. A response to the configuration request is made, and the requested connection may be attempted if the response to the request is affirmative. Under one embodiment, the configuration request and the response to said request are made by InfiniBand devices that are defined by the Specification.

Under the Specification, an InfiniBand module is a unit that, at minimum, consists of an InfiniBand board, a carrier module, and a protective cover. The Specification provides that a module will include at least one InfiniBand link, a baseboard management agent, one InfiniBand management link agent (an interface to the InfiniBand management

link), one module management entity, and the applications the module performs. Pursuant to one embodiment, such a module may request an expanded connectivity configuration. Under this embodiment, the request would be made to an InfiniBand chassis management entity, which is part of an InfiniBand chassis. Under the Specification, an InfiniBand management link (abbreviated as "IB-ML") is defined, and such management link will connect devices on an InfiniBand module with an InfiniBand chassis. The management link allows communication between the chassis and the module entities, and is available even when the InfiniBand fabric is not operational and before a link is connected. Under this embodiment, the InfiniBand management link is used in a novel way not discussed in the Specification to provide a mechanism for making the connectivity request and the resulting response. Under one embodiment, a module requests an expanded connectivity configuration by making the request to the chassis management entity through the management link, and the chassis management entity responds through the management link regarding whether the chassis can support the requested connectivity configuration. The invention is not limited to a physical InfiniBand management link, but may also include communication using a virtual InfiniBand management link or other connection.

Under one embodiment, the configuration request by a module and the response by a chassis management entity may be made by writing to a memory space. According to one embodiment, the request is written to a configuration register in the vendor/product specific space in the management link's serial electrically erasable read only memory (SEEPROM). When a configuration request is made, the response by the chassis management entity to said request is written to another configuration register in

the management link's SEEPROM. If the module detects a positive response to the module's request, the module then attempts to establish a connection over the requested links.

Figure 3 is an illustration of a typical InfiniBand backplane connection. As shown in figure 3, a module **300** contains a management link agent **305** and a module management entity **310**. Module **300** is connected to chassis **315**, which contains chassis management entity **320**. Module **300** and chassis **315** are connected by InfiniBand backplane connector **325**. The connection is comprised of InfiniBand link **330**, InfiniBand management link **335**, and the power connections, which are comprised of bulk power connection **340** and auxiliary power connection **345**. Chassis **315** includes InfiniBand management link SEEPROM **350**. In this configuration, InfiniBand link **330** is limited to a single 1X, 4X, or 12X link that utilizes the physical lanes specified in Table 1.

As shown in Figure 4, an embodiment may comprise a module **400** containing management link agent **405** and module management entity **410**. Module **400** is connected to chassis **415**, which includes chassis management agent **420**. Module **400** and chassis **415** are connected via InfiniBand backplane connector **425**. The connection is comprised of InfiniBand link **430**, InfiniBand management link **435**, and the power connections, bulk power connection **440** and auxiliary power connection **445**. Chassis **415** includes InfiniBand management link SEEPROM **450**. According to this embodiment, module **400** is operable to request an expanded connectivity configuration from chassis **415**. The module communicates the configuration request to chassis management entity **420** of chassis **415**. The request is communicated using InfiniBand

management link **435**. According to this embodiment, module **400** writes the configuration request to a first configuration register **455** in the SEEPROM **445** for InfiniBand management link **430**. Chassis management entity **420** detects the configuration request that has been written to the first configuration register **455**. Upon detecting a configuration request, chassis management entity **420** issues a response to the module by writing the response to a second configuration register **460** in SEEPROM **450**. The response that is written to second configuration register **460** indicates whether the chassis management entity can support the requested connectivity configuration. If module **400** detects a positive response to the configuration request, module **400** then attempts to establish the requested links.

Figure 5 contains a flow chart that illustrates the operation of an InfiniBand module according to one embodiment. In process block **500**, the module determines what connectivity configuration is needed. If the request is for a configuration that is expanded beyond those provided in the Specification, process block **505**, the module requests this configuration by writing the configuration request to a register in the InfiniBand management link SEEPROM, process block **510**. The module detects the response regarding the configuration request, process block **515**. If the response is in the affirmative, process block **520**, the module will initiate the links contained in the requested configuration, process block **525**, and commence operations, process block **530**. According to this embodiment, if the response to the configuration request is not in the affirmative, process block **520**, because the configuration request is denied or because the chassis does not respond to the request, the module will again formulate a configuration request, process block **500**, and proceed through the process defined. If a

request is not for an expanded configuration, process block **505**, then the process may proceed according to the Specification. In this case, the module will follow the specified requirements for normal link establishment, process block **535**, and proceed to initiate the configuration, **525**, and commence operations, process block **530**.

Figure 6 contains a flow chart that illustrates the operation of an InfiniBand chassis according to one embodiment. From this point of view, the chassis attempts to detect any configuration request that has been written to a register in the management link SEEPROM. If there is a request present on a register, process block **605**, the chassis will determine whether the configuration request can be provided, process block **610**. If the request can be provided, the chassis writes an affirmative response to the request to a register in the management link SEEPROM, process block **615**, and proceeds to commences operations, process block **620**. If the configuration request cannot be provided, process block **610**, the chassis will write a negative response to a register in the management link SEEPROM, process block **625**, and again attempt to detect a configuration request on a register in the management link SEEPROM, process block **600**. If no configuration request is present on a register in the management link SEEPROM, process block **605**, then the chassis will follow the requirements contained in the Specification for normal link establishment, process block **630**, and proceed to commence operations, process block **620**.